Barcelona Supercomputing Center
Centro Nacional de Supercomputación

EXCELENCIA SEVERO OCHOA

How to predict future climates

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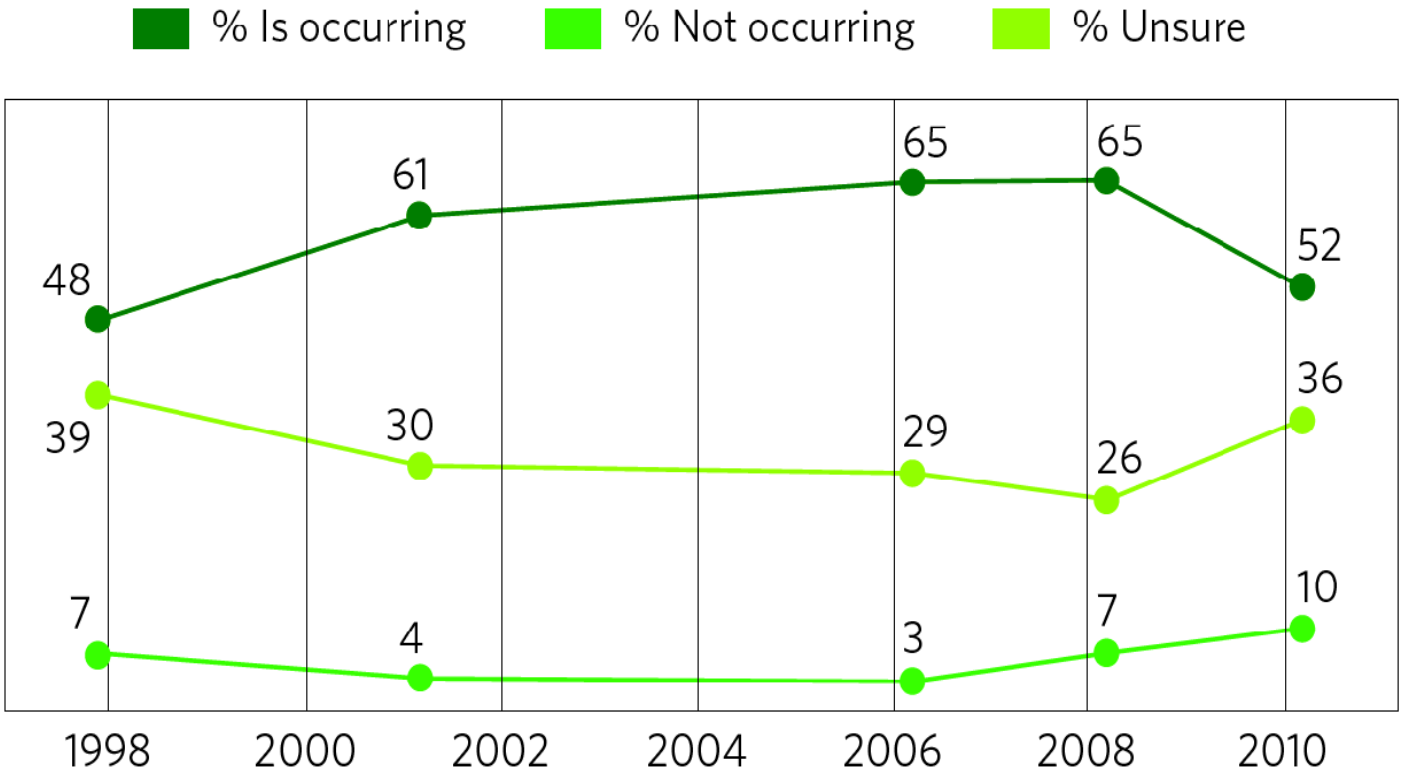
Centro Nacional de Supercomputación

Should we trust climate predictions?

Francisco J. Doblas-Reyes

What this presentation is not about

Results to asking the question "which one of the following statements is most accurate: most scientists believe that global warming is occurring, most scientists believe global warming is not occurring, or most scientists are unsure about whether global warming is occurring or not?"



Pidgeon and Fischhoff (2011)

Should we care? International help

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Environ Health Perspect; DOI:10.1289/ehp.1306640

Soil Dust Aerosols and Wind as Predictors of Seasonal Meningitis Incidence in Niger

Carlos Pérez García-Pando,[1,2*] Michelle C. Stanton,[3,4,*] Peter J. Diggle,[3,5] Sylwia Trzaska,[6] Ron L. Miller,[1,2] Jan P. Perlwitz,[1,2] José M. Baldasano,[7] Emilio Cuevas,[8] Pietro Ceccato,[6] Pascal Yaka,[9] and Madeleine C. Thomson[6,10]

theguardian
Winner of the Pulitzer prize

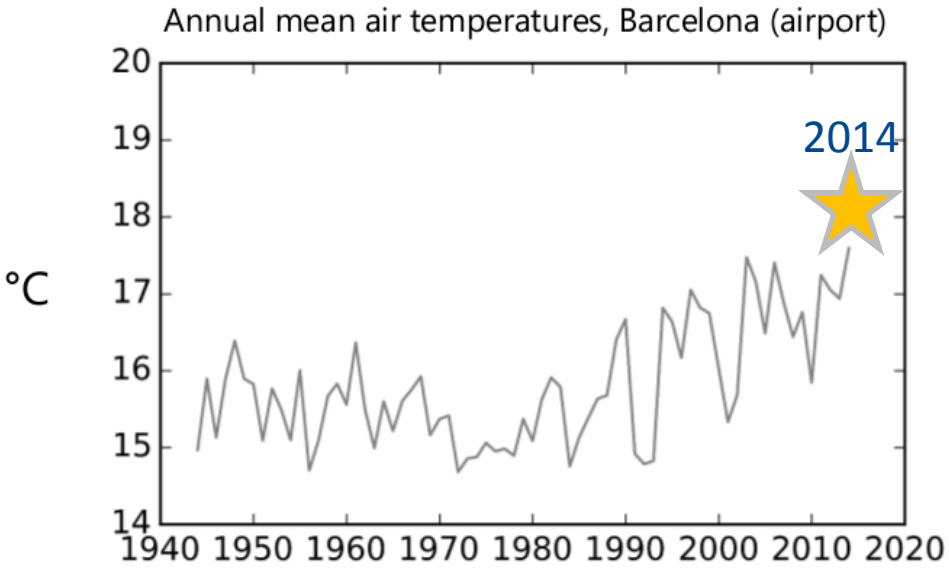
Sahel meningitis outbreaks linked to wind and dust levels, claim scientists

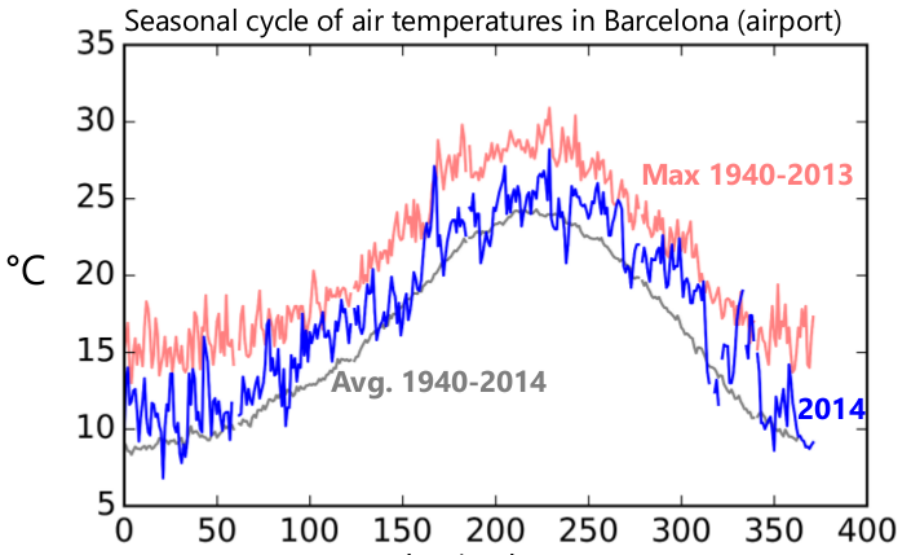
Researchers collaborate with health officials to plan vaccination campaigns after discovering how to predict seasonal outbreaks

A donkey throws up dust in Chad's Mao region. Research suggests wind and dust levels can be used to predict meningitis epidemics. Photograph: Rebecca Blackwell/AP

Should we care? A closer example

Temperatures in Barcelona airport from the ECAD dataset.

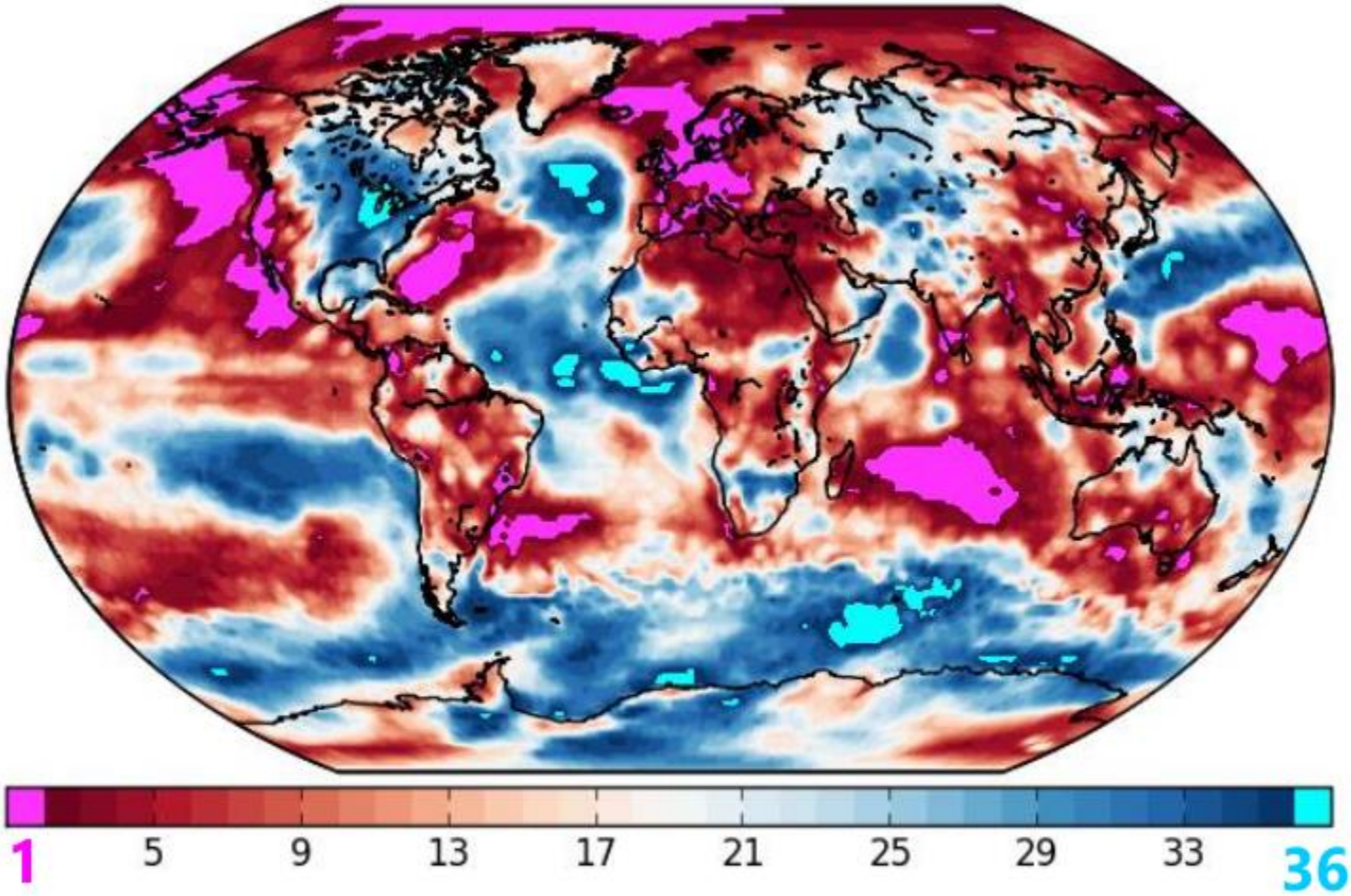




François Massonnet (IC3)

Should we care? A global example

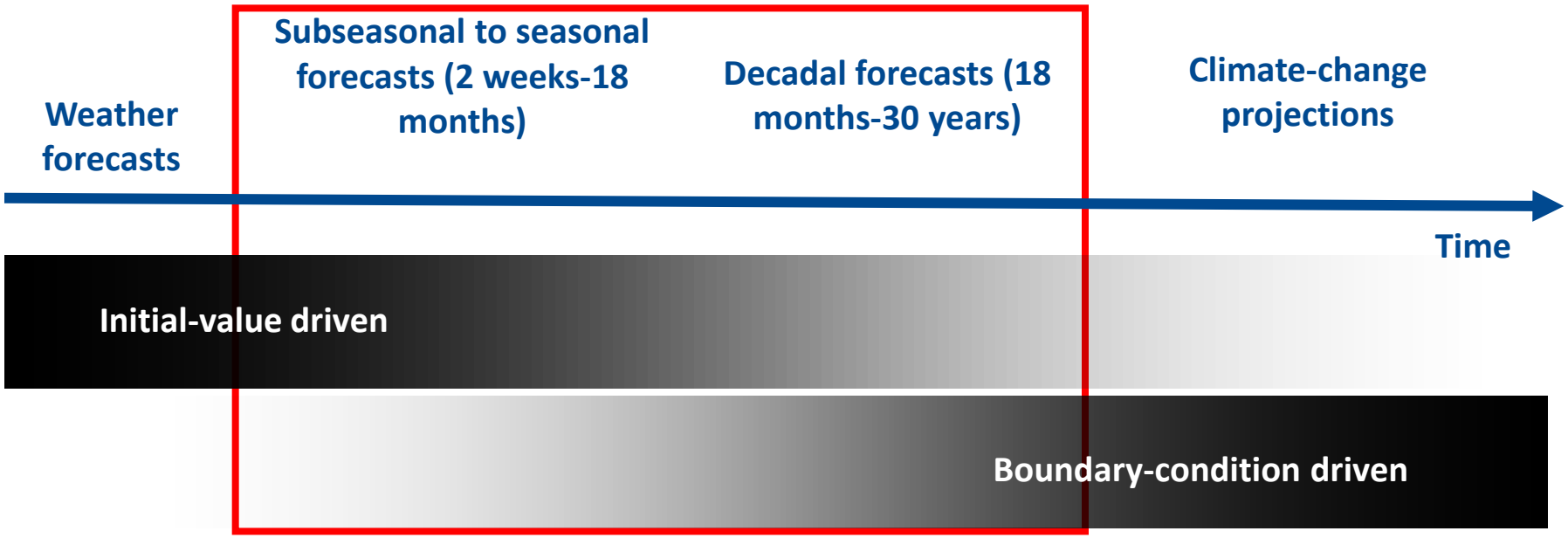
Rank of the 2014 annual mean temperature over the last 36 years from ERA Interim.



François Massonnet (IC3)

Climate prediction time scales

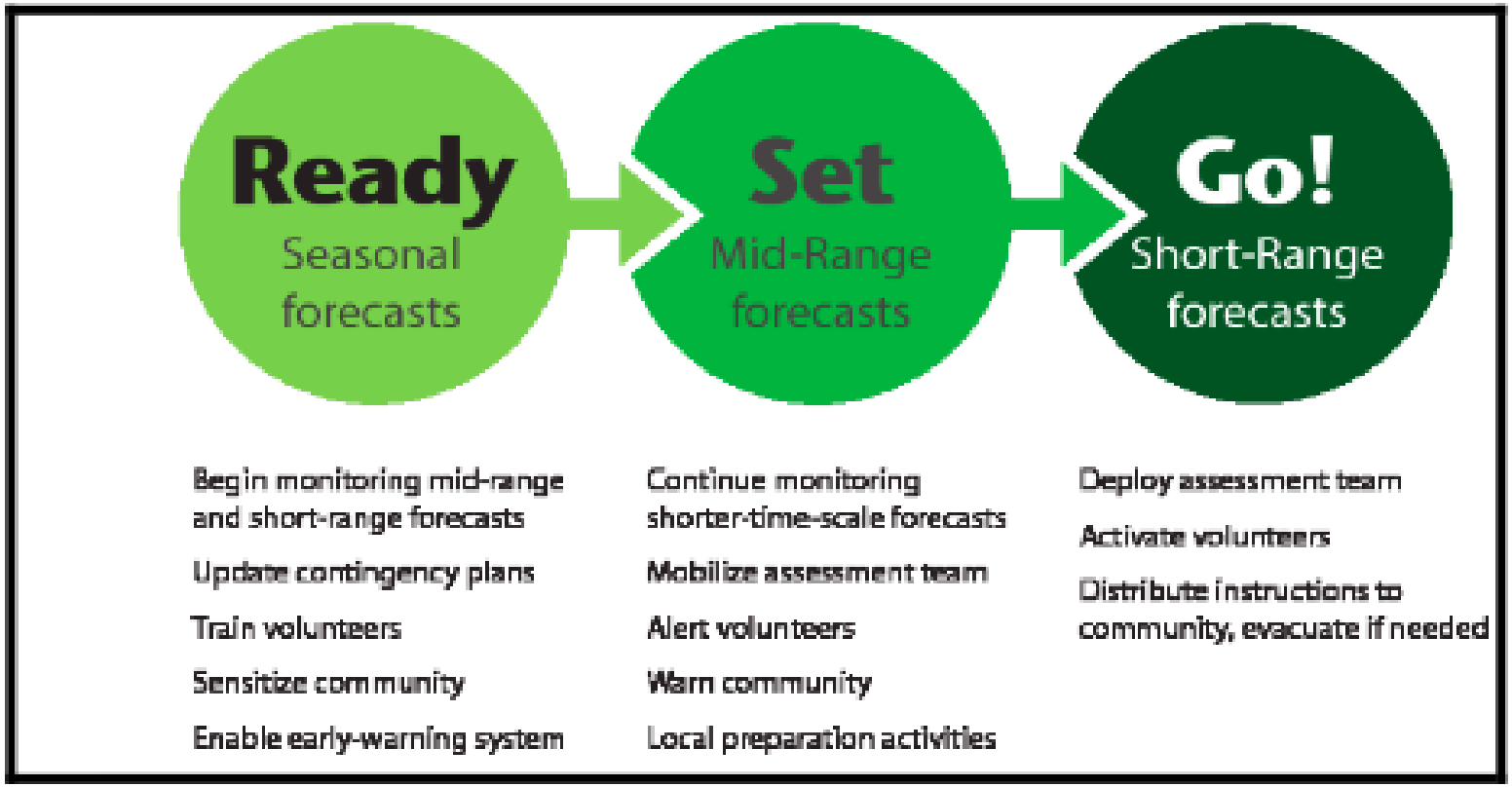
Progression from initial-value problems with weather forecasting at one end and multi-decadal to century projections as a forced boundary condition problem at the other, with climate prediction (sub-seasonal, seasonal and decadal) in the middle. Prediction involves initialization and systematic comparison with a simultaneous reference.



Adapted from Meehl et al. (2009)

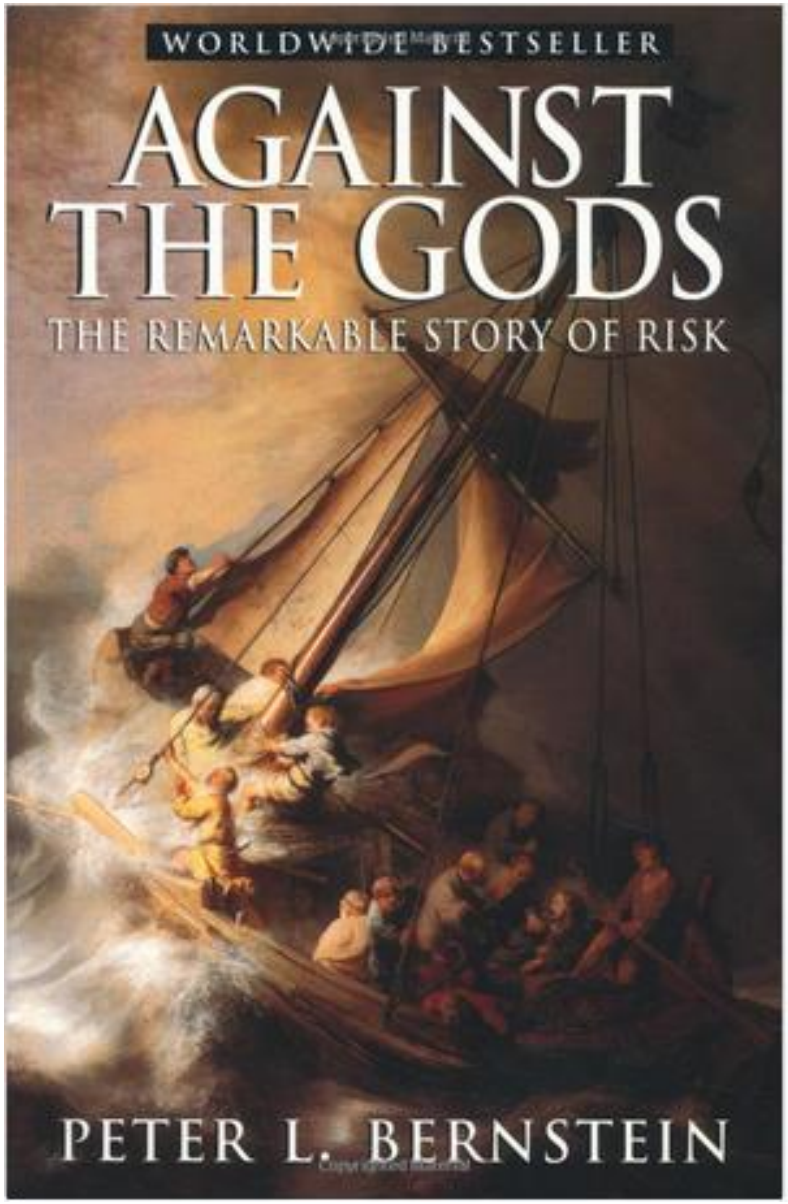
Seamless prediction, adaptation

Application of seamless climate and weather information. Example from the IRI-Red Cross collaboration.



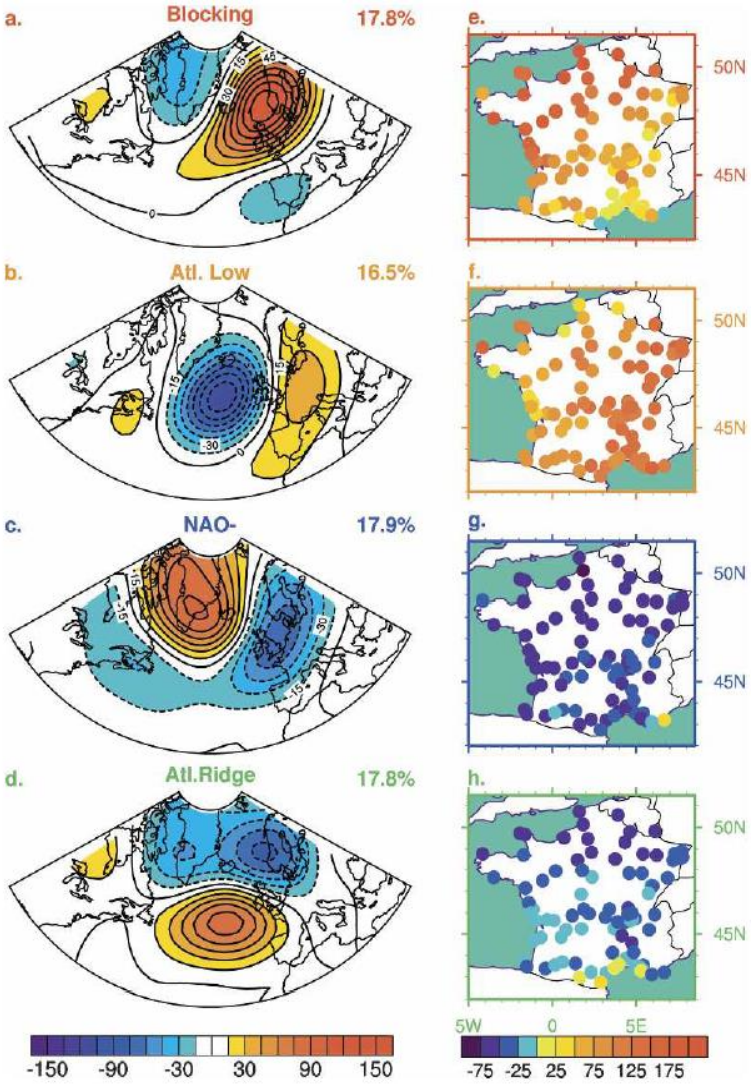
IRI

Modelling of risk management



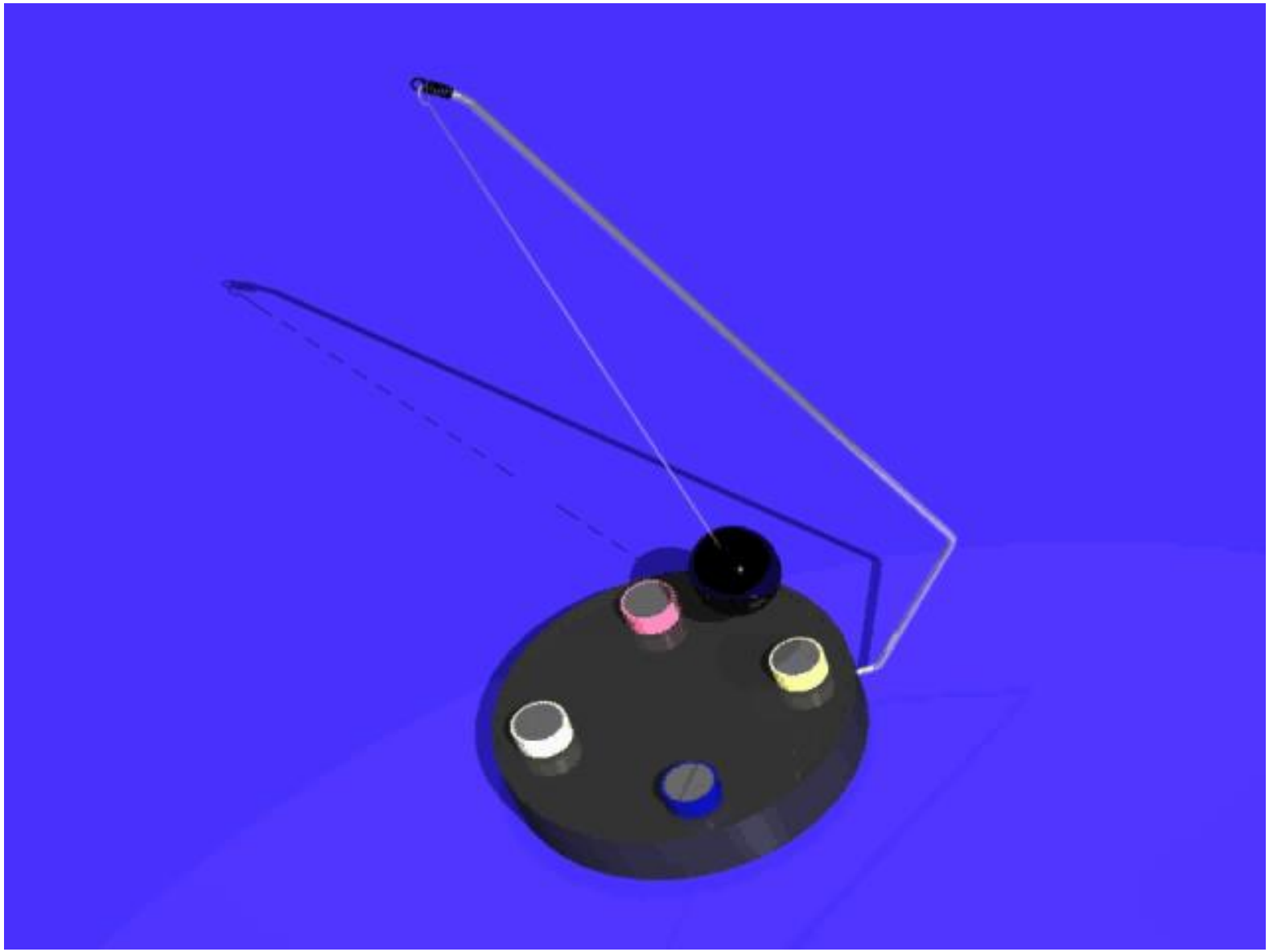
A metaphor of atmospheric circulation

Mid-troposphere (500 hPa geopotential height) summer (JJA) weather types and frequency change (%) of warm days over France.

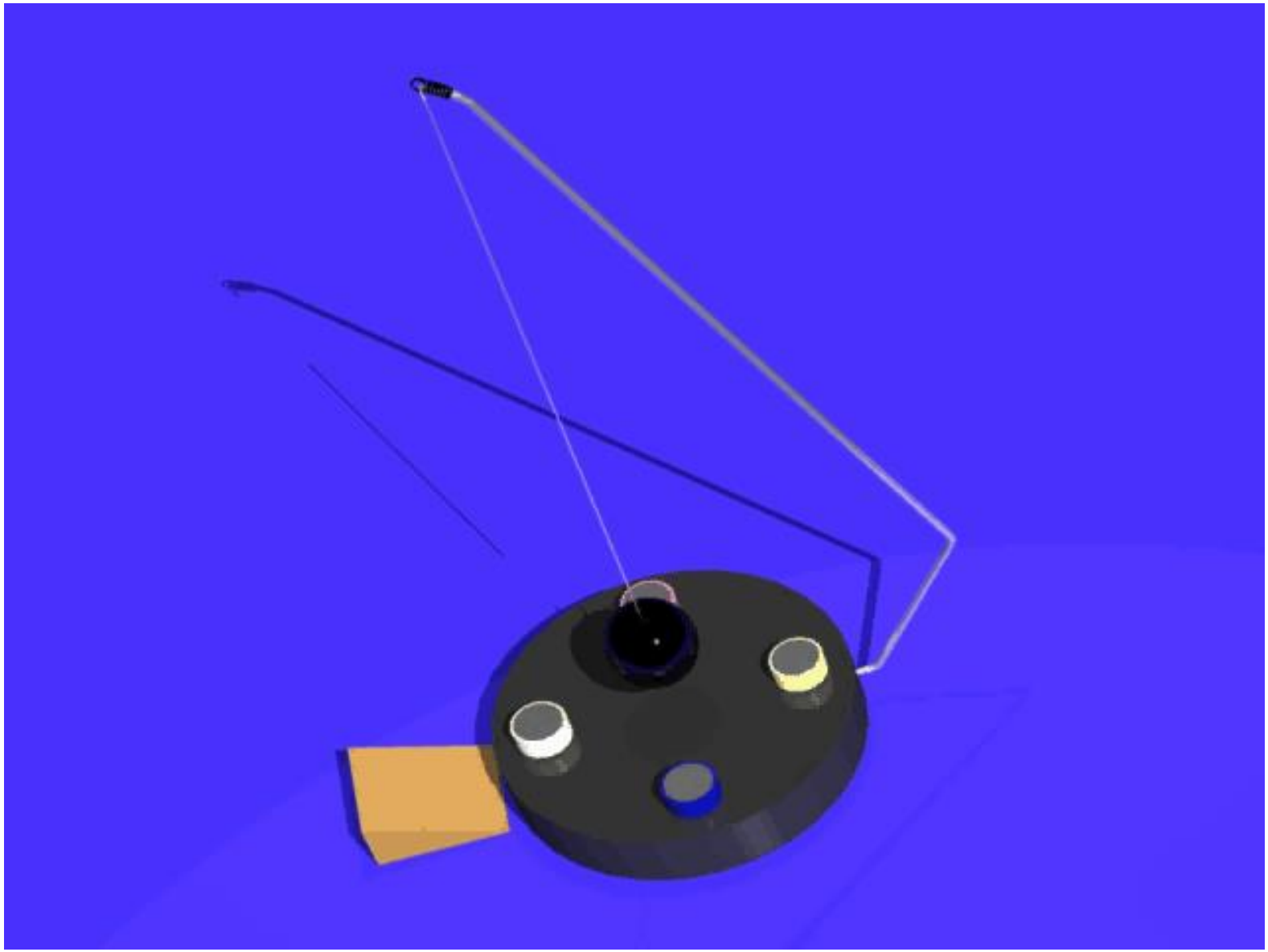


Cassou et al. (2005)

A metaphor of atmospheric circulation



A metaphor of atmospheric circulation



What could the wedge be

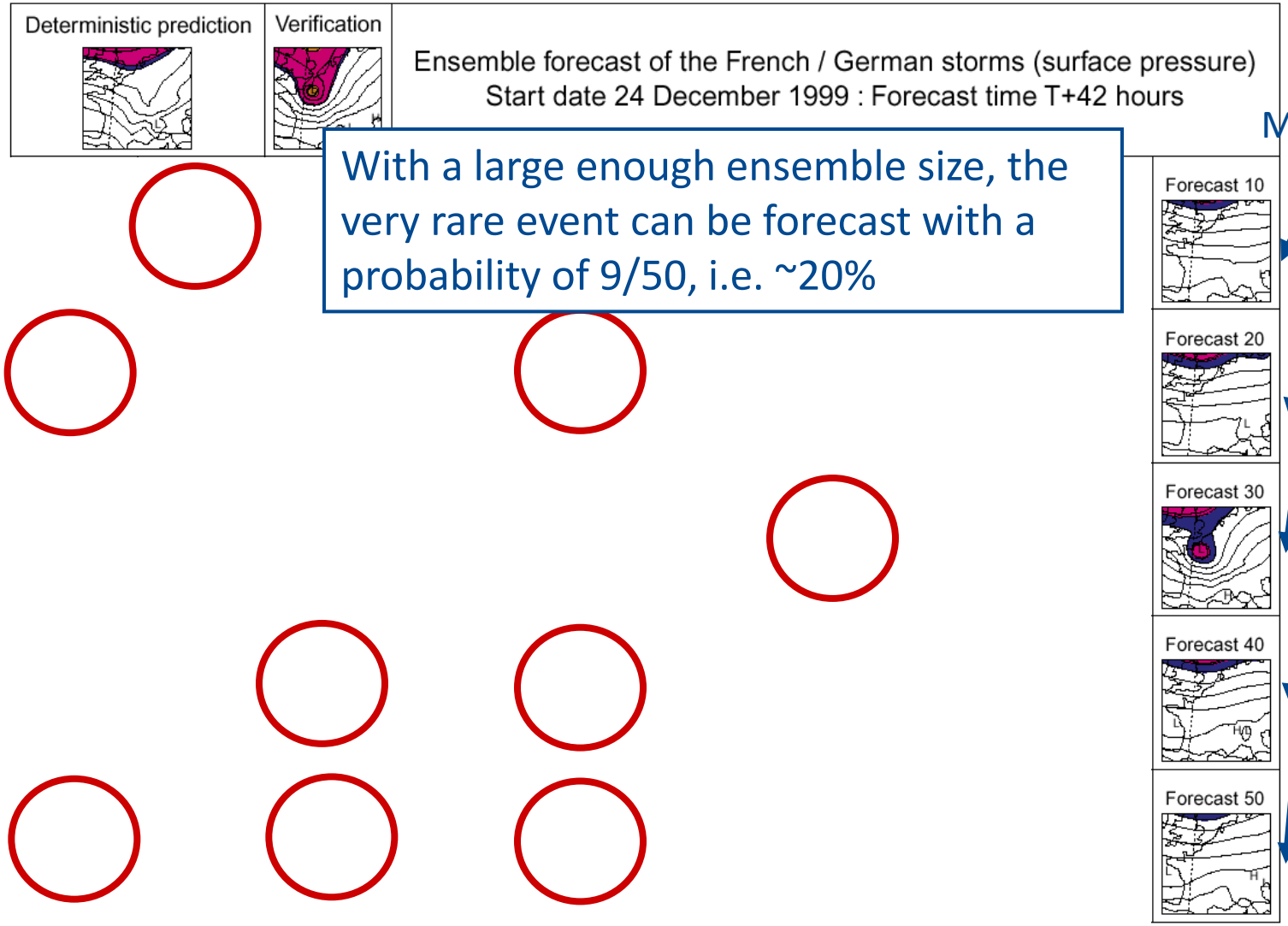
- Important:
  - ENSO - biggest signal at seasonal
  - Other tropical ocean SST - difficult
  - Climate change - very important
  - Local land surface conditions - soil moisture, snow
  - Atmospheric composition - difficult but indispensable
- Other factors:
  - Volcanic eruptions - important for large events
  - Mid-latitude ocean temperatures - still somewhat controversial
  - Remote soil moisture/snow cover - rising importance
  - Sea-ice anomalies - at least local effects
  - Stratospheric influences - various possibilities
- Unknown or unexpected

Producing dynamical predictions

- Build a climate model (atmosphere, ocean, sea ice, land surface)
- Prepare initial conditions
- Initialize coupled system
  - The aim is to start the system close to reality. Accurate SST is particularly important, plus ocean sub-surface. Usually, worry about “imbalances” a posteriori.
- Run an ensemble forecast
  - Explicitly generate an ensemble on the e.g. 1st of each month, with perturbations to represent the uncertainty *in the initial conditions*; run forecasts for several months.
- Produce probability forecasts from the ensemble
- Apply calibration and combination if significant improvement is found
- Valid predictions can also be produced with empirical methods.

Running large ensembles

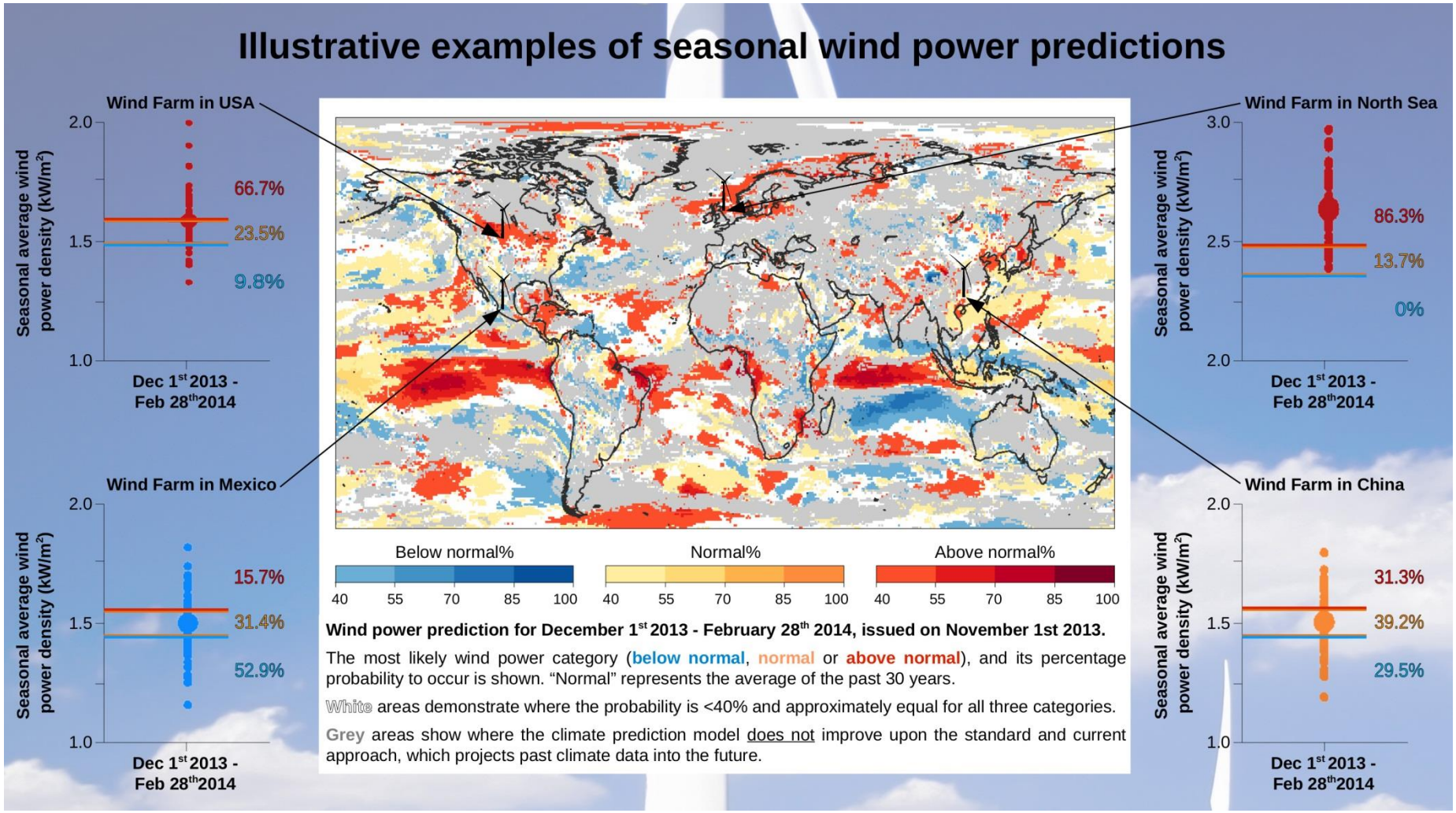
ECMWF forecasts (D+42) for the storm Lothar.



A metaphor for the ensemble method

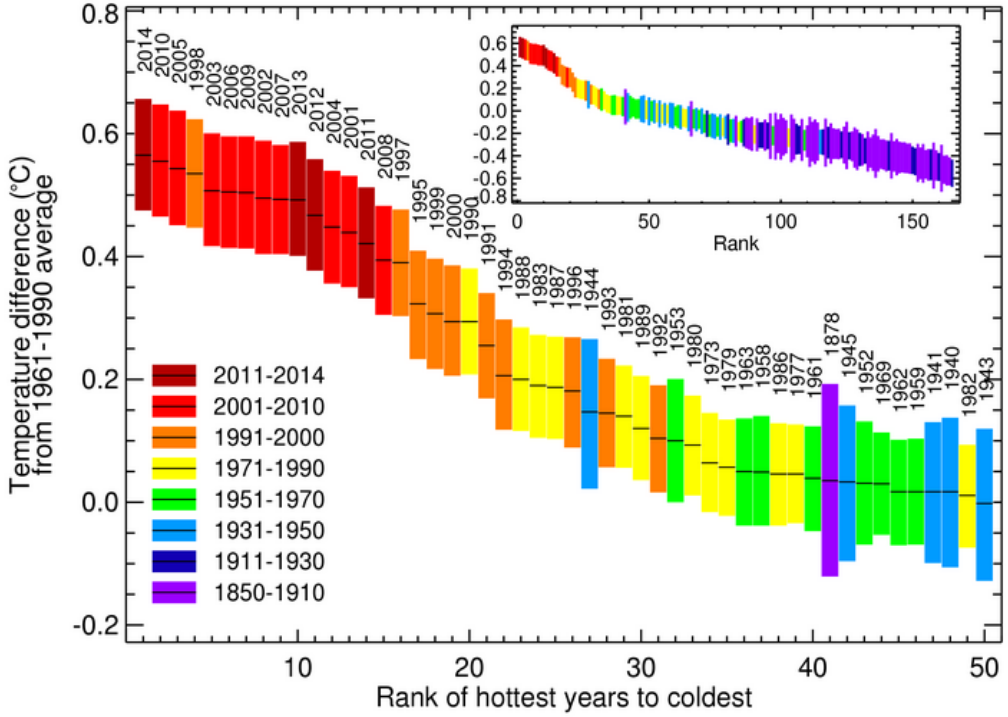
- Ensembles of simulations are made to take into account the unavoidable uncertainty in all modelling exercise.
- Ensembles are converted into probabilistic forecasts to provide privileged information to the users, away from determinism.
- Consider the case of playing “lotería primitiva”. In its simplest version, there are 49 numbers of which 6 are selected.
- The chances of getting all six right (the big prize) is 1 in 13,983,816.
- Imagine we know that number 49 has a high probability of not being drawn. With this information, chances are 1 in 12,271,512.
- Imagine that the privileged information is that it is unlikely that even numbers are drawn. Then, the chances are 1 in 177,100, around 100 times higher than with no information.
- Would you bet now? How much higher should your chances, compared to other players, be to risk your resources?

The climate data produced



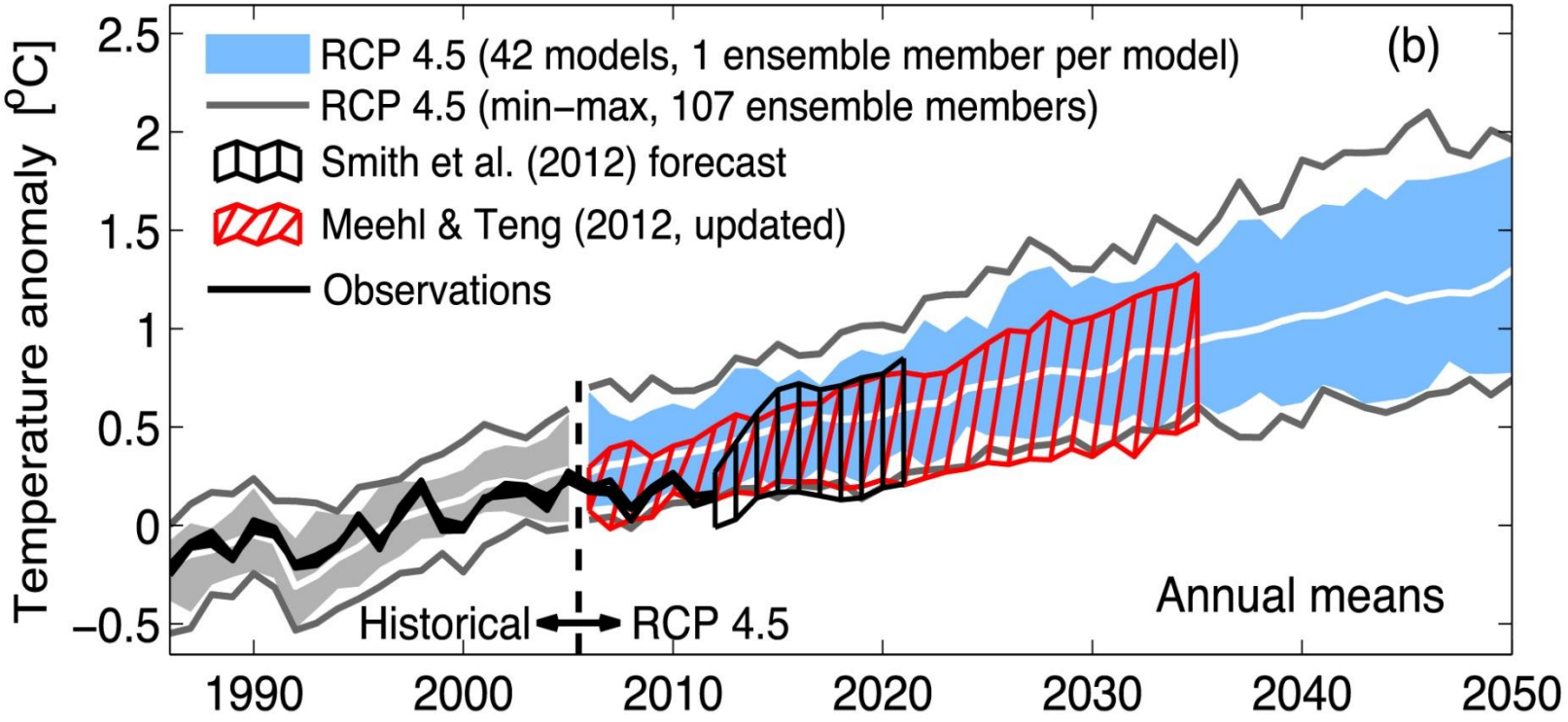
The climate data produced

The Met Office issued in December 2013 a forecast (using their global temperature forecast system) for global average temperature in 2014 to be expected between 0.43 and 0.71 above the long-term (1961-1990) average: “Taking into account the range of uncertainty in the forecast, it is likely that 2014 will be one of the warmest ten years in the record



The climate data produced

Annual-mean global-mean temperature predictions and projections from CMIP5.



IPCC AR5 WGI (2013)

What we currently do

Multi-model real-time decadal prediction exchange will request additional support at CCl16. Very simple: research exercise, we can learn a lot from this; prevent over-confidence from a single model.

http://www.metoffice.gov.uk/research/climate/seasonal-to-decadal/long-range/decadal-multimodel

Multi-model decadal forecast exchange

The Met Office coordinates an informal exchange of near-real time decadal predictions. Many institutions around the world are developing decadal prediction capability and this informal exchange is intended to facilitate research and collaboration on the topic.

The contributing prediction systems are a mixture of dynamical and statistical methods. The prediction from each institute is shown below, alongside an average of all the models. When possible, observations for the period of the forecast are also shown. Currently three variables are included: surface air temperature, sea-level pressure and precipitation. These are shown as differences from the 1971-2000 baseline. More diagnostics, including ocean variables are planned for the future. Please use the drop-down menus below to explore the data collected to date.

This work is supported by the European Commission SPECS project.

SPECS

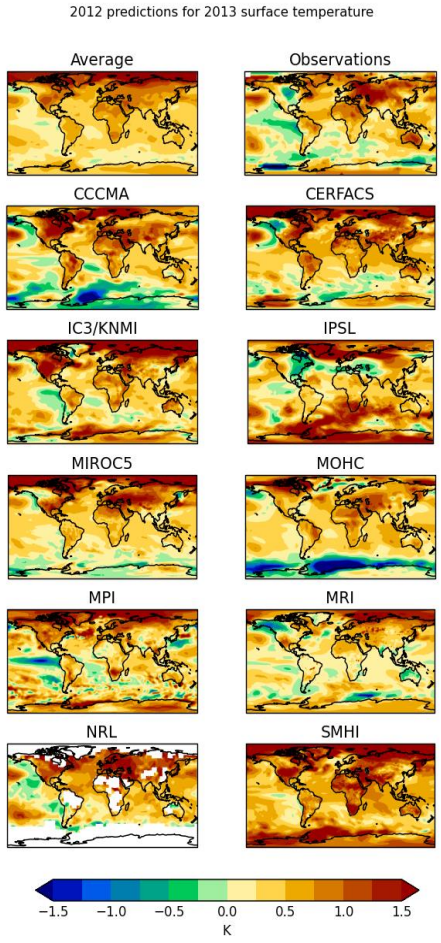
Seasonal-to-decadal climate Prediction for the improvement of European Climate Services

To learn more about decadal forecasts at the Met Office, see our current decadal forecast.

Images last updated 2014-06-25

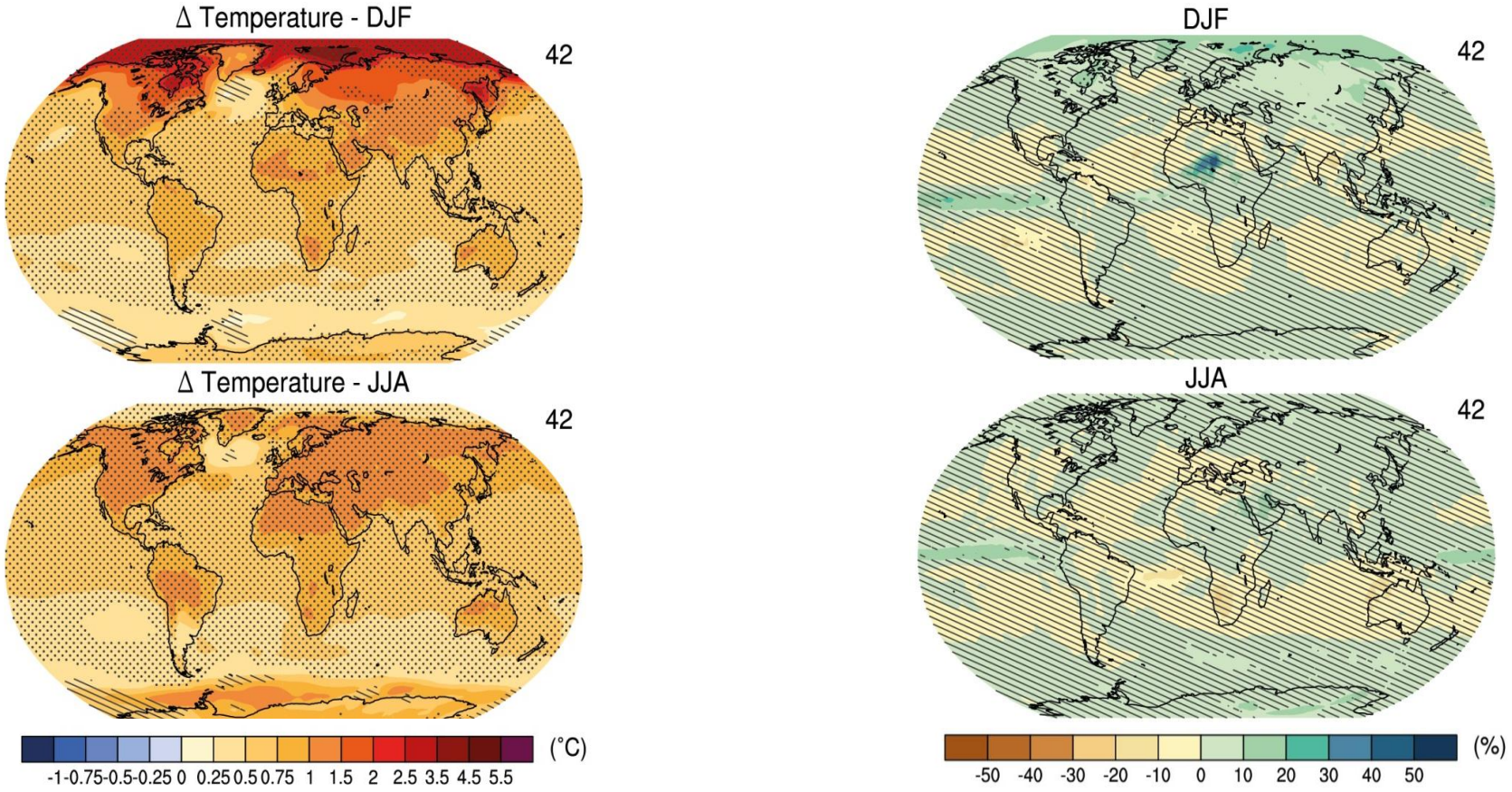
Issued	Period	Element
2013	year 1	surface air temperature

Decadal forecast exchange 2013 predictions for year 1 surface air temperature



What will still exist in the next years

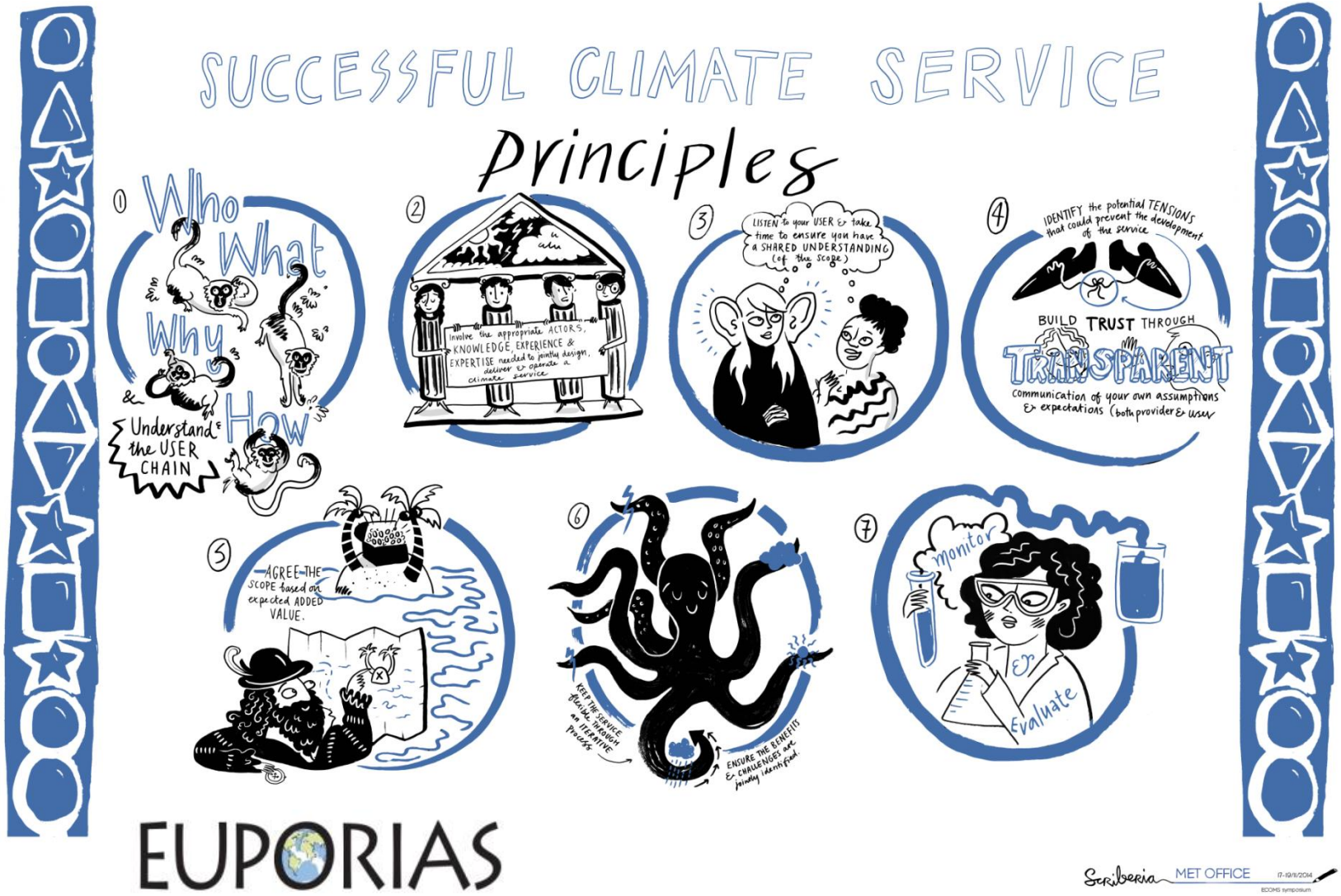
Seasonal-mean air temperature and percentage precipitation change for the RCP4.5 scenario from CMIP5 over 2016-2035 (wrt 1986-2005). Stippling for significant changes, hatching for non-significant.



IPCC AR5 WGI (2013)

Climate services

Climate data is not climate information.



The future BSC-ES: Objectives

What

Environmental forecasting

Why

Our strength …
- … research …
- … operations …
- … services …
- … high resolution …

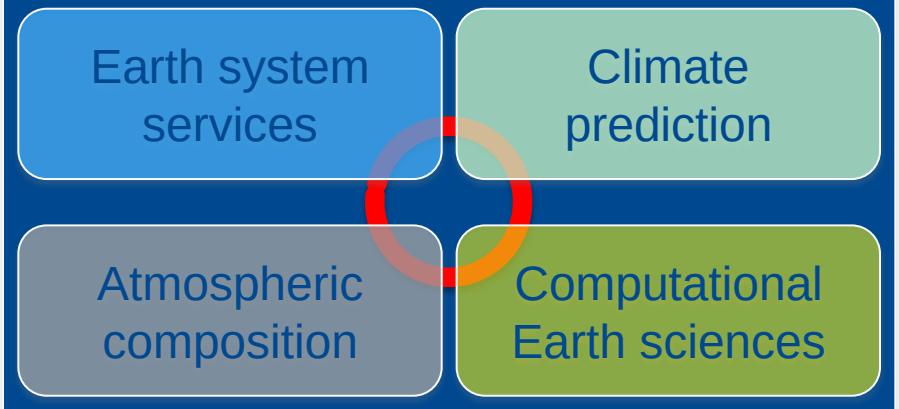
How

Develop a capability to model air quality processes from urban to global and the impacts on weather, health and ecosystems

Implement climate prediction system for subseasonal-to-decadal climate prediction

Develop user-oriented services that favour both technology transfer and adaptation

Use cutting-edge HPC and Big Data technologies for the efficiency and user-friendliness of Earth system models



www.bsc.es

Thank you

For further information please contact
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